



Reconnaissance



A tradition of honor, a legacy of valor... from first flight to satellite

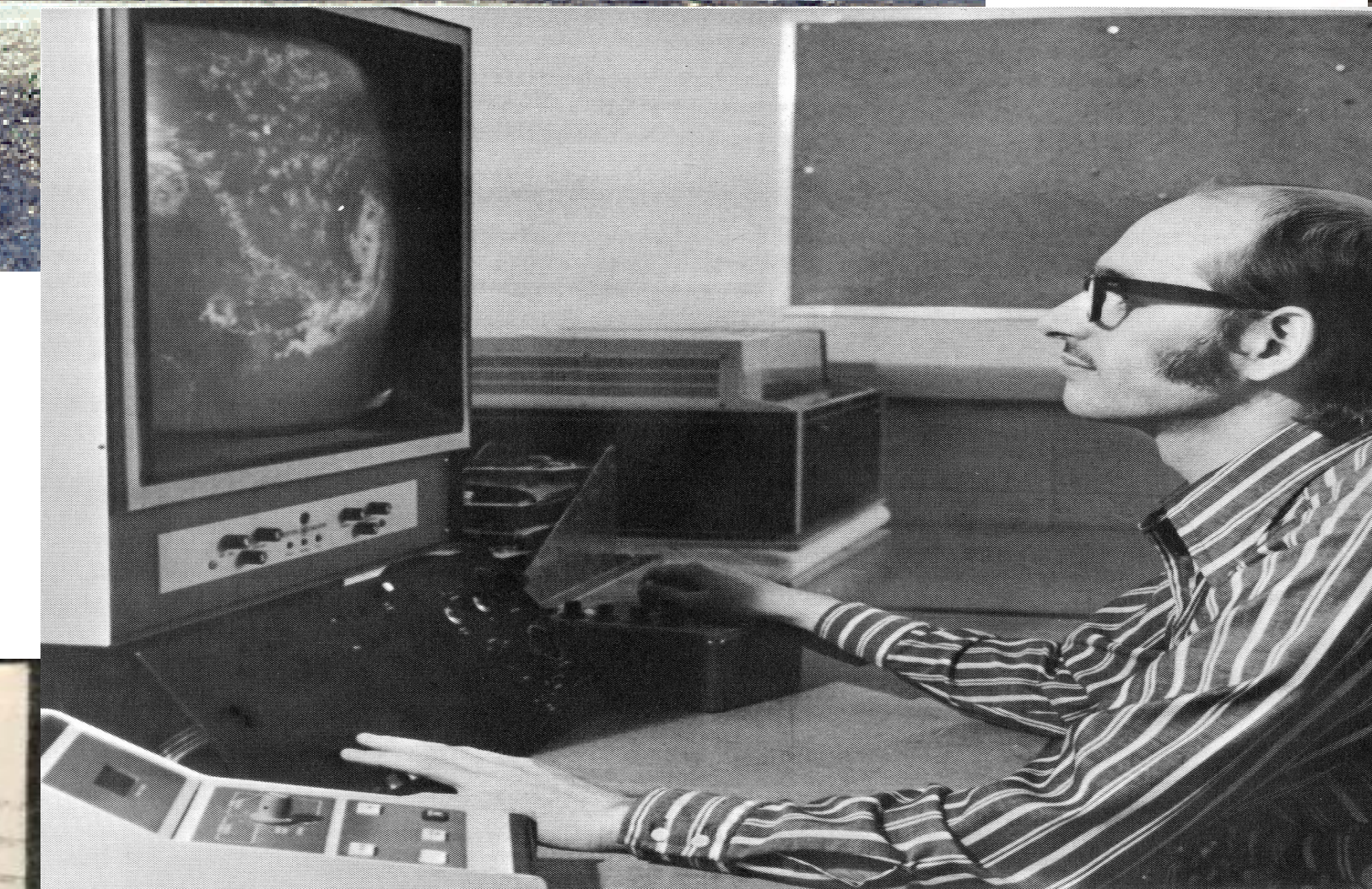
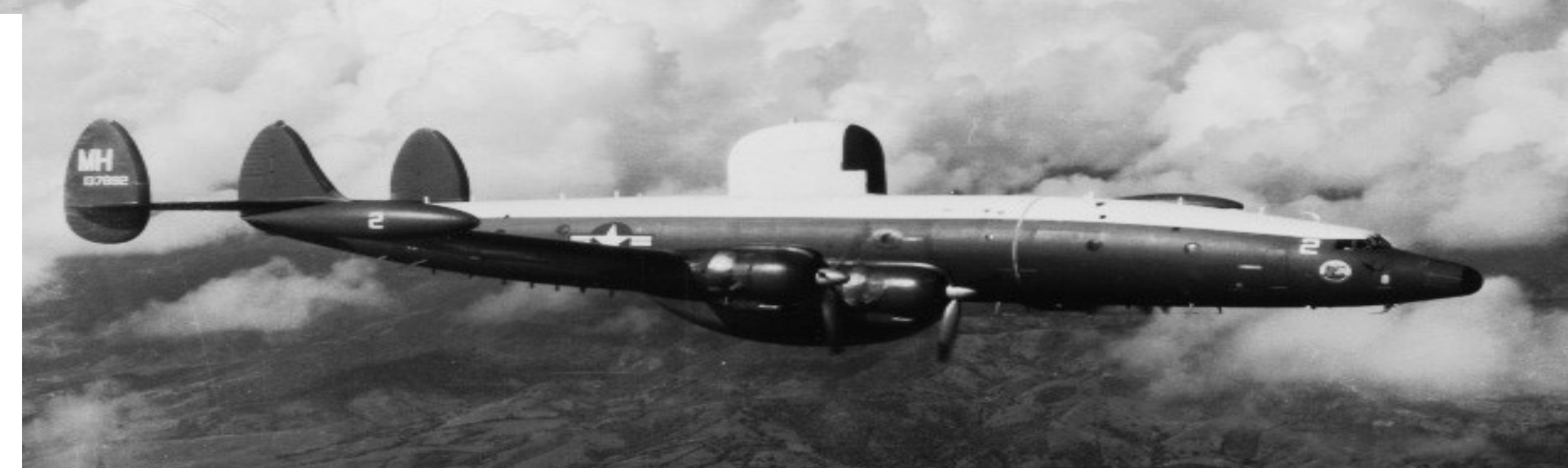
Manned aerial weather reconnaissance begins in January 1945 with the arrival of the 655th Bombardment Squadron on Guam. The 655th later re-designated the 54th Weather Reconnaissance Squadron, Andersen AFB, Guam.



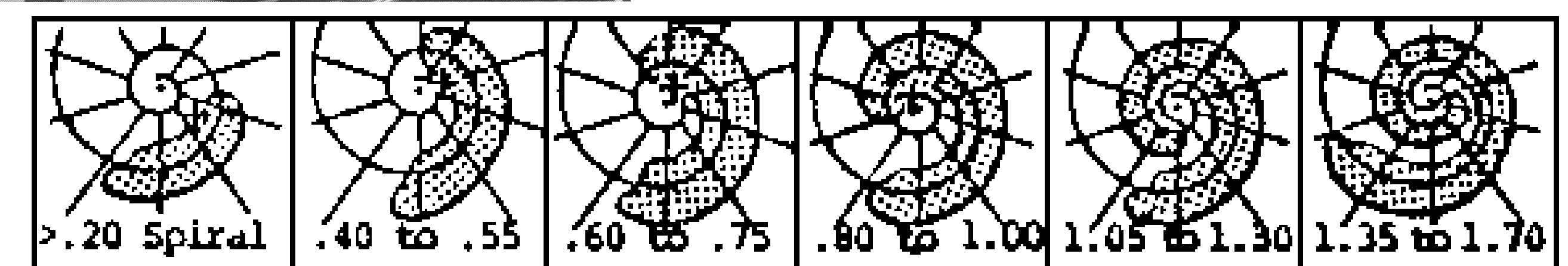
B-24 aircraft used to conduct en route and target weather reconnaissance, eventually transitioning to the WB-29 airframe.



Other aircraft used include the Super Constellation, flown by the Airborne Early Warning Squadron One (VW-1) from Naval AirStation, Guam, and the WC-130.



Dawn of satellite meteorology - TIROS-1 and ATS-1 Spin Scan Cloudcover Camera (SSCC) photograph earth from low-altitude and geosynchronous orbit.



Subjective Dvorak tropical cyclone intensity estimation technique developed using visible and infrared data.

1940

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1950

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1960

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1970

S





Reconnaissance



A tradition of honor, a legacy of valor... from first flight to the future!

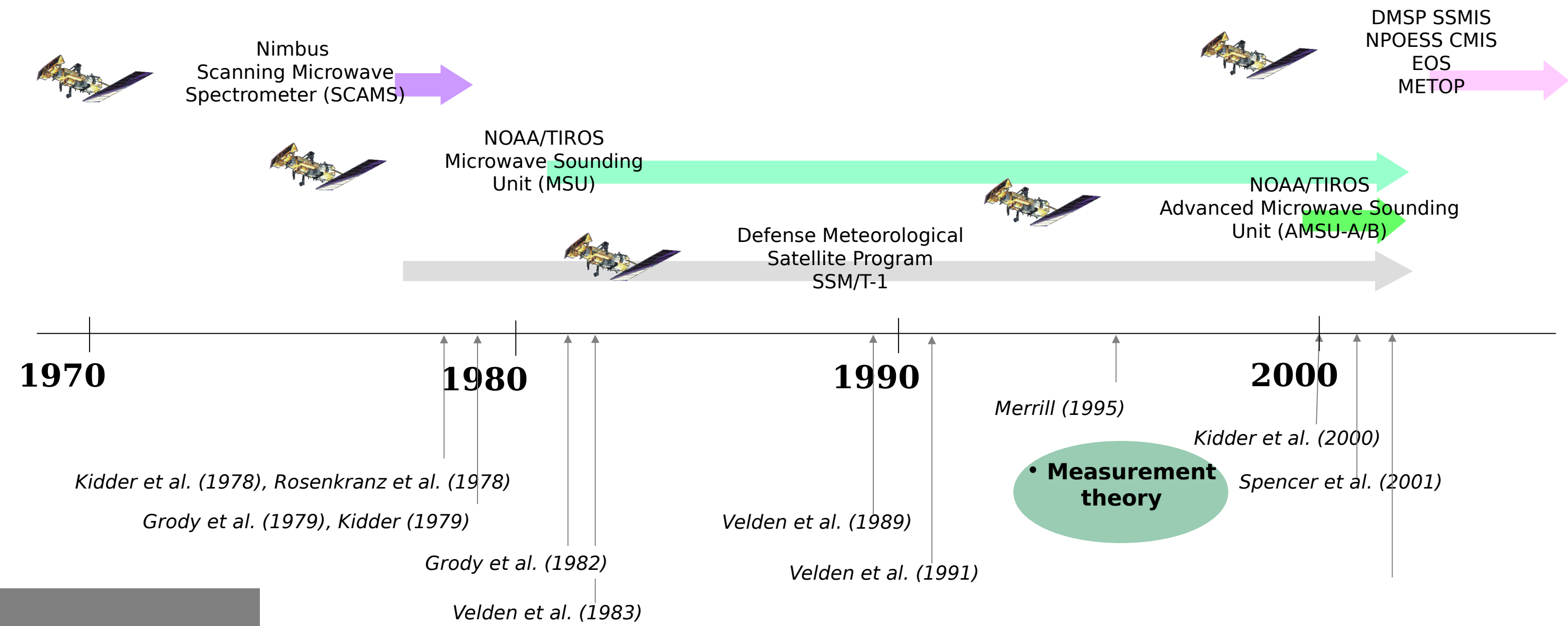
1980s



Era of decades-long improvement in understanding and exploiting polar-orbiting satellite passive microwave sensor data.

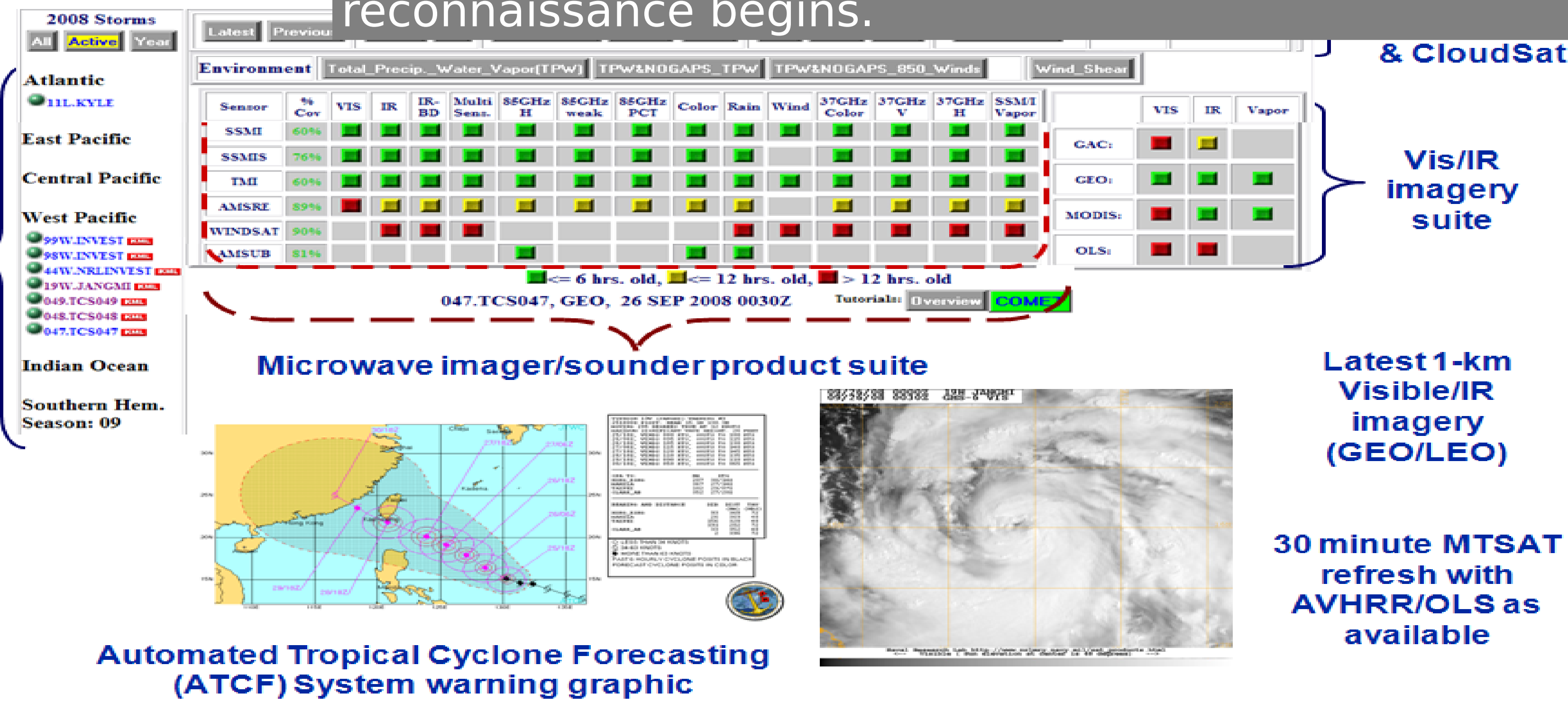


54th Weather Reconnaissance Squadron decommissioned – era of satellite-based tropical cyclone reconnaissance begins.



1990s

Storm Basins & Names



& CloudSat

Vis/IR imagery suite

Latest 1-km Visible/IR imagery (GEO/LEO)

30 minute MTSAT refresh with AVHRR/OLS as available

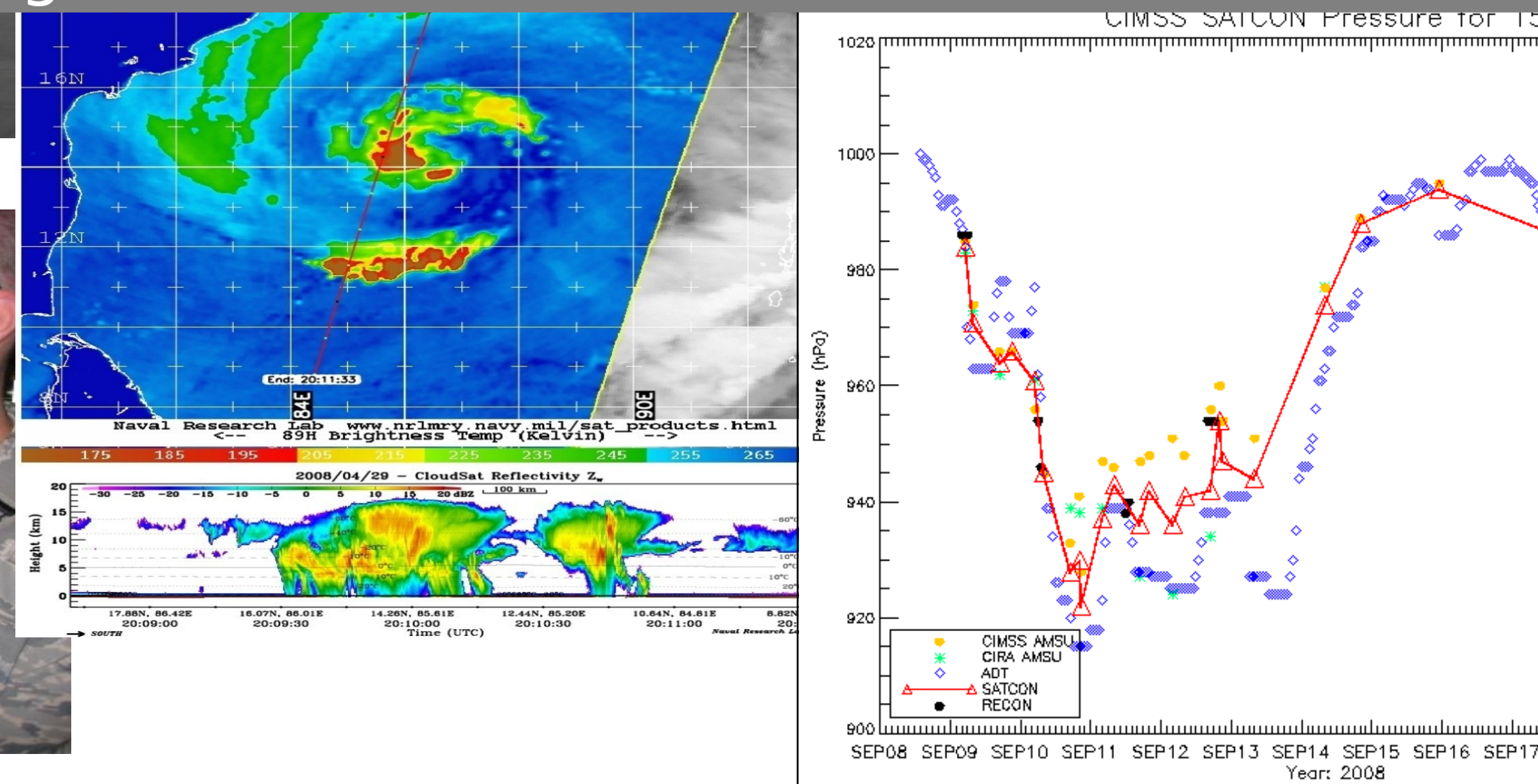
Automated objective Dvorak and passive microwave satellite intensity techniques mature and are increasingly utilized.

2000s

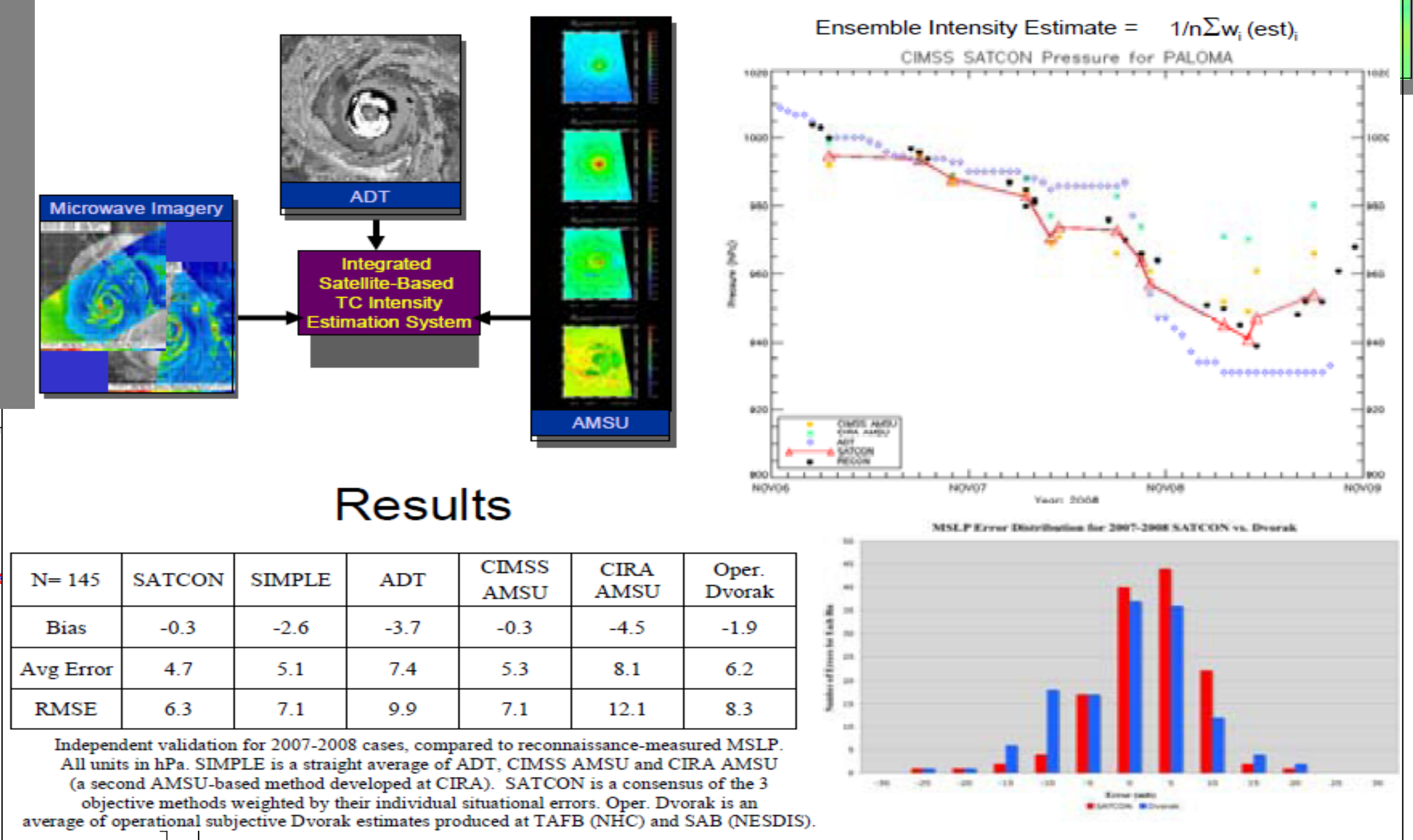
S



Data fusion, distributed collaboration and exploitation of internet tools and technology enables tremendous operational synergy – combination of scatterometer data, cloud track winds, multi-spectral imagery and passive microwave observations offer unprecedented insight.



SATellite CONsensus (SATCON)



Futur
e



The Navy and Air Force jointly participate in the 2008 THORPEX Pacific Asian Regional Campaign (T-PARC) and Tropical Cyclone Structure (TCS) Experiment to validate automated objective satellite techniques for potential further operational exploitation in the Pacific theater.





Tropical Cyclone Forecasting

... **The Obvious Need**



17-19 Dec 1944



Equipped with relatively poor information and a strong determination to carry out his mission to protect General MacArthur's flank during the invasion of the Philippine island of Mindoro, Admiral Halsey's Third Fleet fell victim to the havoc of Typhoon Cobra 300 miles east of Luzon Island.

Fleet Weather Center (FWC) at Pearl Harbor did provide typhoon warnings but it incorrectly forecasted the typhoon to move north, well to the east of the fleet. The Third Fleet Aerological Officer, CDR George F. Kosco, on board the Third Fleet flagship, USS New Jersey, also detected the developing typhoon and actually forecasted a more realistic west movement, but he severely underestimated the typhoon's intensity.



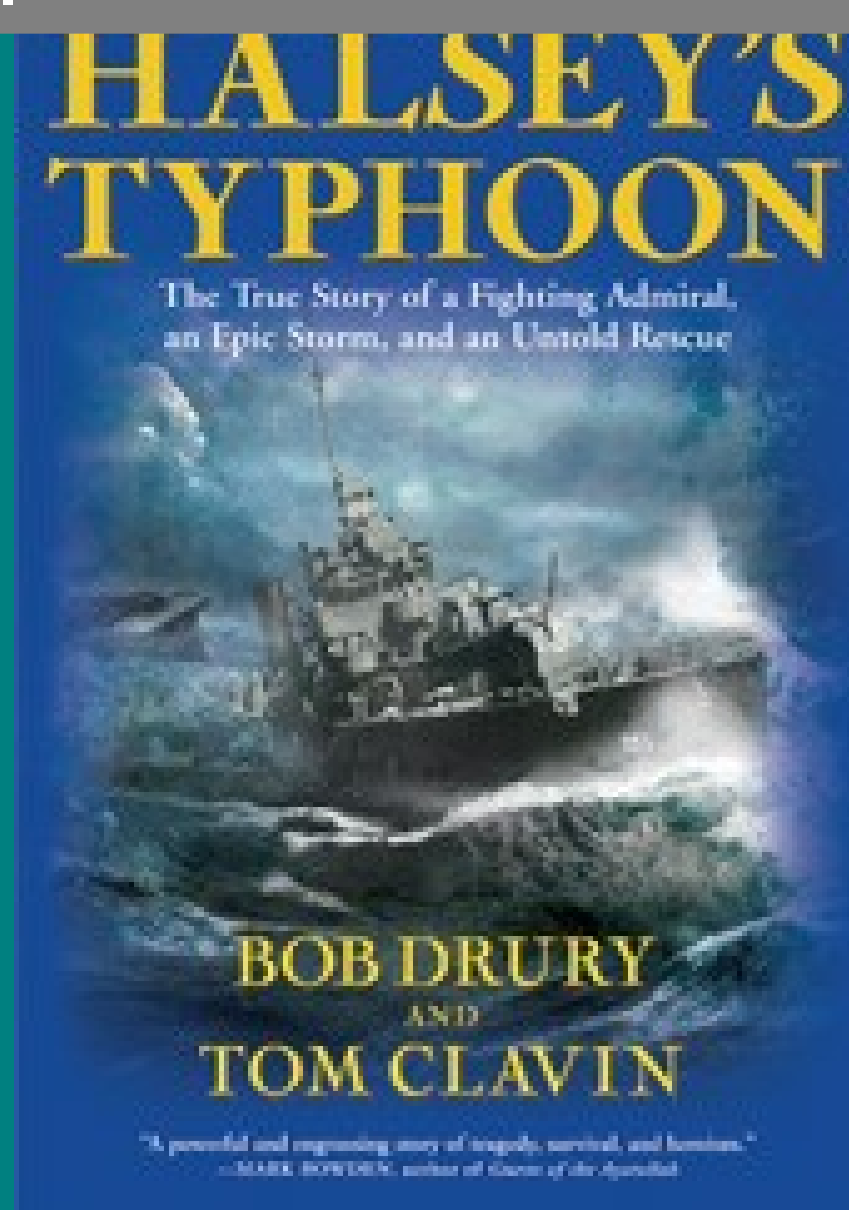
As a result of the inaccurate forecasts, three destroyers capsized (*Hull, Monaghan & Spence*) with the loss of 790 men and 146 aircraft. Serious damage was also inflicted on the aircraft carriers, cruisers, and smaller vessels.



USS Cowpens CVL-25 During Typhoon Cobra



Damaged USS Tabberer DE 418 after the typhoon. This ship rescued 55 of the 98 survivors



In the wake of Typhoon Cobra, a court of inquiry was conducted and Admiral Nimitz, Commander-in-Chief Pacific (CINCPAC), composed a new set of future fleet-wide weather guidelines. These included more reconnaissance aircraft and weather ships stationed across the Western Pacific, a new "weather central" station established on Leyte, and an expansion of the existing station on Guam. (Drury and Clavin, *Halsey's Typhoon*, p. 273)

Jan 1945

The 655th Bombardment Squadron (B-24s), under the command of Lt Col Nick Chavasse, arrived on Guam to conduct en route and target weather reconnaissance.



Patch of 655 Bombardment Squadron/55th Reconnaissance Squadron



B-24L of B Flight, 55th Reconnaissance Squadron, LR, Weather Two Jima
Official USAF Photo, courtesy of the Air Force Weather History Office
May not be used for commercial purposes

May 1945

The Fleet Weather Central / Typhoon Tracking Center (FWC/TTC) was established on Guam, but with no naval aerial reconnaissance dedicated to typhoon tracking missions.

4 Sep 1945

The 54th Weather Reconnaissance Squadron (54WRS) was established at Andersen AFB, while the 55WRS rotated back to the States in 1946.



USS Pittsburgh CA-72, damaged by Typhoon Viper, returned home without her bow

Aug 1945

Admiral Halsey, enroute to Japan to accept their formal surrender, safely maneuvered his fleet between three typhoons with the 55th Reconnaissance Squadron providing 6-hourly updates of the typhoon positions.

4-5 Jun 1945

The Third Fleet was operating around southern Japan and Okinawa and suffering nearly constant Kamikaze attacks, when typhoon warnings indicated the presence of Typhoon Viper to the south-southwest.

16 Jun 1945

The 655th Bombardment Squadron was renamed as the 55th Reconnaissance Squadron.





Tropical Cyclone Forecasting

The Formation of JTWC . . .



JTWC Formation, 1958-

1959

May 1958

The Joint Meteorology Committee to Pacific Command (JMC PACOM) in Hawaii formed and was comprised of representatives from the three services and the United States Weather Bureau. The Pacific Air Force's representative was the First Weather Wing Commander, Colonel Nick Chavasse.

Jun 1958

At the first PACOM Annual Tropical Cyclone Conference (ATCC) at Pearl Harbor, Col Chavasse proposed the formation of a joint Air Force - Navy analysis and typhoon warning center at the Navy's Fleet Weather Central at Nimitz Hill, Guam.

Jan 1959

Based on the report and conclusions reached at PACOM's 1958 ATCC, the JMC PACOM formally urged the Commander in Chief, US Pacific Command (CINCPAC) to establish a Joint Typhoon Warning Center (JTWC) and he in turn petitioned the Joint Chiefs of Staff (JCS).

14 Apr 1959

JCS approved formation of the JTWC under the command of the Nimitz Hill Fleet Weather Central's (FWC) Commanding Officer.

18 Apr 1959

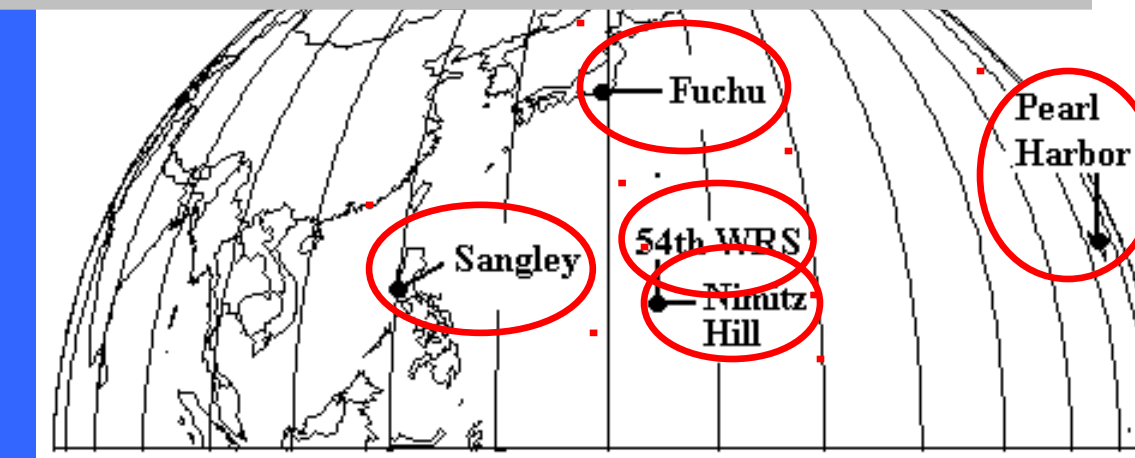
CINCPAC directed that the senior Air Force officer assigned, Lt Col Robert Hoffman, be given the title of Director, JTWC, and be junior in rank to the FWC Commanding Officer, CDR Charles E. Tilden.



1 May 1959

CINCPAC directed the formation of the JTWC under FWC in order to eliminate redundancy and improve efficiency of tropical cyclone monitoring and warning for the northwest Pacific Ocean region. The Alternate Joint Typhoon Warning Center (AJTWC) was located at the Air Force's Fuchu Weather Center and operated as the JTWC contingency alternate with assistance from Fleet Weather Facility, Yokosuka.

KJTHQ/PACAF
INFO RHHB/CINCPAC
RHHB/NET IN CHG SUPP OFF HON
RHHB/JCS
RHHB/CINCPACREPOHARD
RHHB/COMUSARPAC
RHHB/3RD AIRDIV
NAVY CDR
BT
ADMIRAL CINCPAC 182230Z NOTAL.
REQ YOU ESTABLISH EFFECTIVE 1 MAY 59 A JOINT PACIFIC FLEET
PACIFIC AIR FORCES TYPHOON WARNING CENTER INTEGRAL WITH FLEETWEATHER
GUAM. TITLE NOW ENTITY WILL BE FLEET WEATHER CENTRAL/JOINT TYPHOON
WARNING CENTER GUAM UNDER THE COMMAND OF CO FLEETWEATHER GUAM. NO
CHANGE PROPOSED TO FLEETWEATHER RESPONSIBILITIES. MISSION ASSIGNED TO
PROVIDE TROPICAL CYCLONE WARNINGS TO ALL U. S. GOVT AGENCIES WEST
OF 180 DEGREES LONG VIA EXISTING MILITARY AND PAA CIRCUITS AND PRO-
CEDURES. DETERMINE TYPHOON RECOGNIZABLENESS AND PRIORITIES; CONDUCT
INVESTIGATIVE AND POST ANALYSIS PROGRAM INCLUDING PREPARATION OF
ANNUAL TYPHOON SUMMARIES. CONDUCT FORECAST AND DETECTION RESEARCH
AS PRACTICABLE. LOGISTIC AND ADMINISTRATIVE SUPPORT AS MUTUALLY
AGREED. JTWC SHALL BE STAFFED INITIALLY BY TWO OFFICERS AND THREE
ENLISTED EACH FROM THE EXISTING ALLOWANCES OF FLEETWEATHER GUAM AND
FIRST WEATHER WING. THE SENIOR AIR FORCE OFFICER ASSIGNED SHALL BE THE DIRECTOR.
JTWC AND SHOULD BE JUNIOR TO THE CO FLEETWEATHER GUAM. THE TROPIC WEATHER
CENTRAL FUCHU ASSISTED AS NECESSARY BY FLEETWEATHER YOKOSUKA IS DESIGNATED ALTERNATE
JTWC IN CASE OF FAILURE OF FLEETWEATHER/JTWC GUAM.
BT
23/0213Z APR 1959



Post WWII Tropical Cyclone Warning Network
- The Air Force had the primary center at Fuchu Weather Center, and a smaller detachment located at Andersen AFB with the 54th WRS, each having typhoon warning responsibilities for Air Force and Army installations in the Pacific.

-The Navy had weather centers at Pearl Harbor, Hawaii; Nimitz Hill, Guam; and Sangley

tropical cyclone warning
Naval assets and

28 Jun 1959

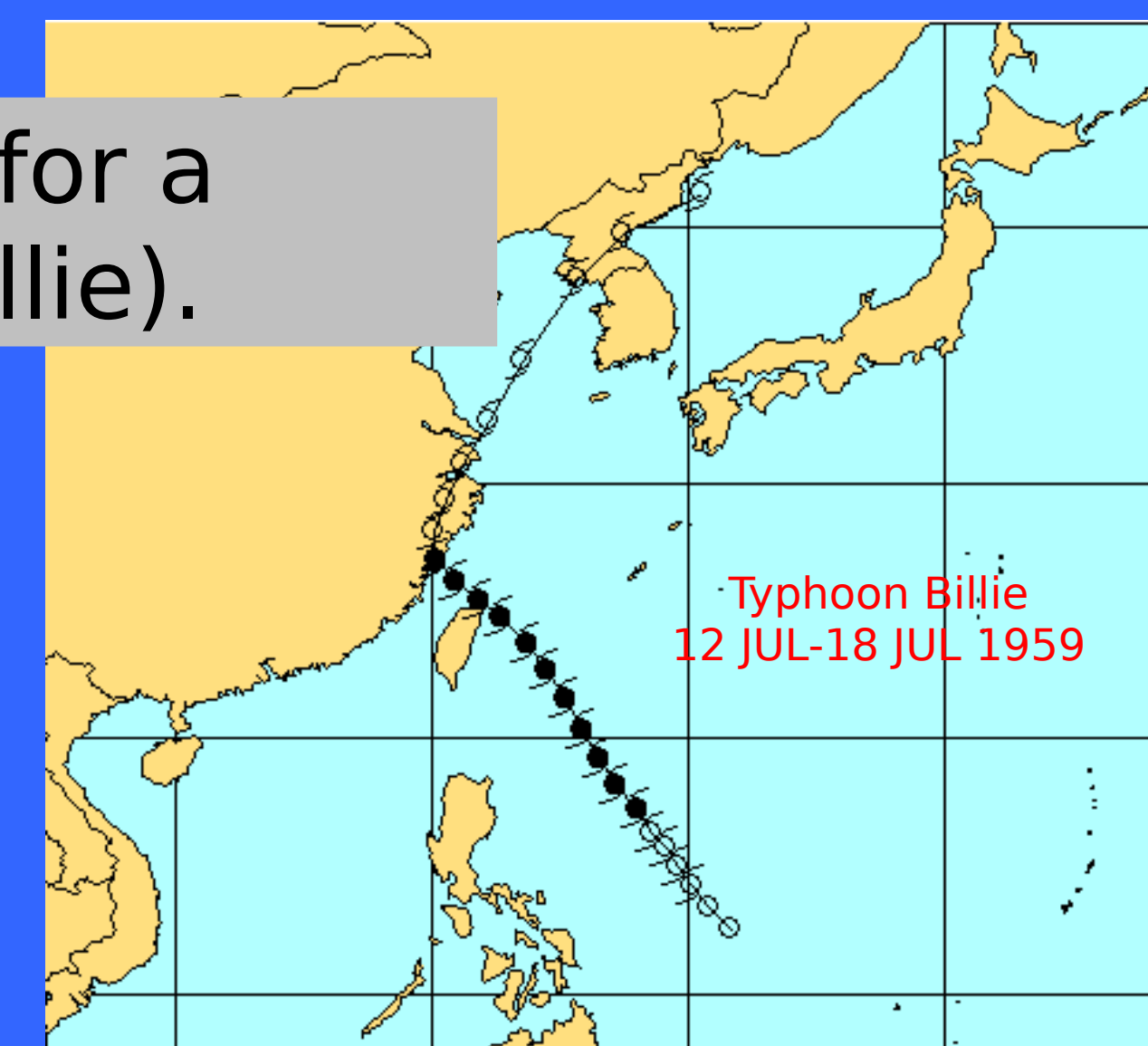
First warning issued by FWC/JTWC (Tropical Depression Violet)

4 Jul 1959

First warning issued for Tropical Storm (Wilda).

13 Jul 1959

First warning issued for a typhoon (Typhoon Billie).



Timeline of JTWC

Events

1959 JTWC manned by two USAF and two USN weather officers, as well as six enlisted personnel--three from each service. The senior of the two USAF meteorologists is the Director of JTWC.

- Warnings issued four times daily out to 48 hours for each TC in the Northwest Pacific Ocean.

1961 JTWC manning increased to three weather officers each from the USAF and USN.

1962 JTWC Northwest Pacific Ocean TC forecasts extended to 72 hours, but not on a routine basis.

11 Nov 1962 Typhoon Karen destroys the Quonset hut that housed the Fleet Weather Center/Joint Typhoon Warning Center. A typhoon-resistant annex to the ex-COMNAVMARIANAS Headquarters building becomes operational in 1965.



Typhoon Karen
7 NOV-18 NOV 1962

Typhoon Karen was a Super Typhoon when it slammed into Guam. It was also reported to have two eye walls due to an eyeball replacement cycle at landfall. On November 11, while over Guam, the cyclone had winds of 160+ mph and a minimum central pressure of at least 934 millibars. It maintained Super Typhoon intensity for 4.25 days, second only to Typhoon Nancy in length.



1967 JTWC starts writing Prognostic Reasoning messages for TC's of tropical storm strength or greater. JTWC also starts issuing the Significant Weather Advisory for the Northwest Pacific Ocean from May through December.

1968 JTWC warnings issued with alternating 48-hour and 72-hour forecasts and tropical depression warning forecasts valid out to 24 hours.

1971 JTWC area of responsibility expanded to include the Bay of Bengal; north of the Equator between the Malay Peninsula and 90E.

1972 JTWC manning increased to four weather officers from each service and all warnings were extended to 72 hours.





Joint Typhoon Warning Center

Timeline of JTWC Events Continued . . .



1975 JTWC AOR expanded to include all of the north Indian Ocean. Significant Tropical Weather Advisory for the Pacific Ocean (ABPW) and the Indian Ocean (ABIO) issued daily throughout the entire year.

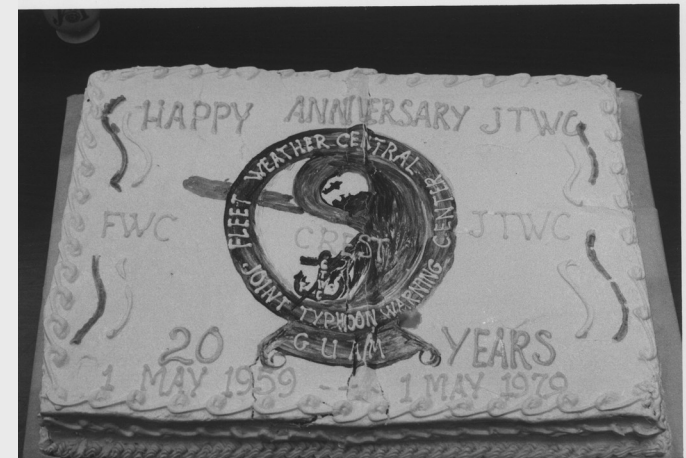
1977 Tropical Cyclone Model (TCM) used in track forecasting
- AJTWC responsibility shifted to FWC Pearl Harbor.

1978 Naval Environmental Display Station (NEDS) installed at FWC/JTWC Guam.



1979 JTWC celebrates its 20th birthday!

1980 Nested Tropical Cyclone Model (NTCM) evaluated and found to be less skilled than One Way Interactive - TCM (OTCM).



1981 JTWC assumes responsibility to warn on all TC's in the northern and southern hemispheres west of the Dateline.

- Manning now 4 USAF officers (Director and 3 TDO's), 5 USN Officers (Deputy Director and 4 TDO's) and 4 USAF and 6 USN enlisted.

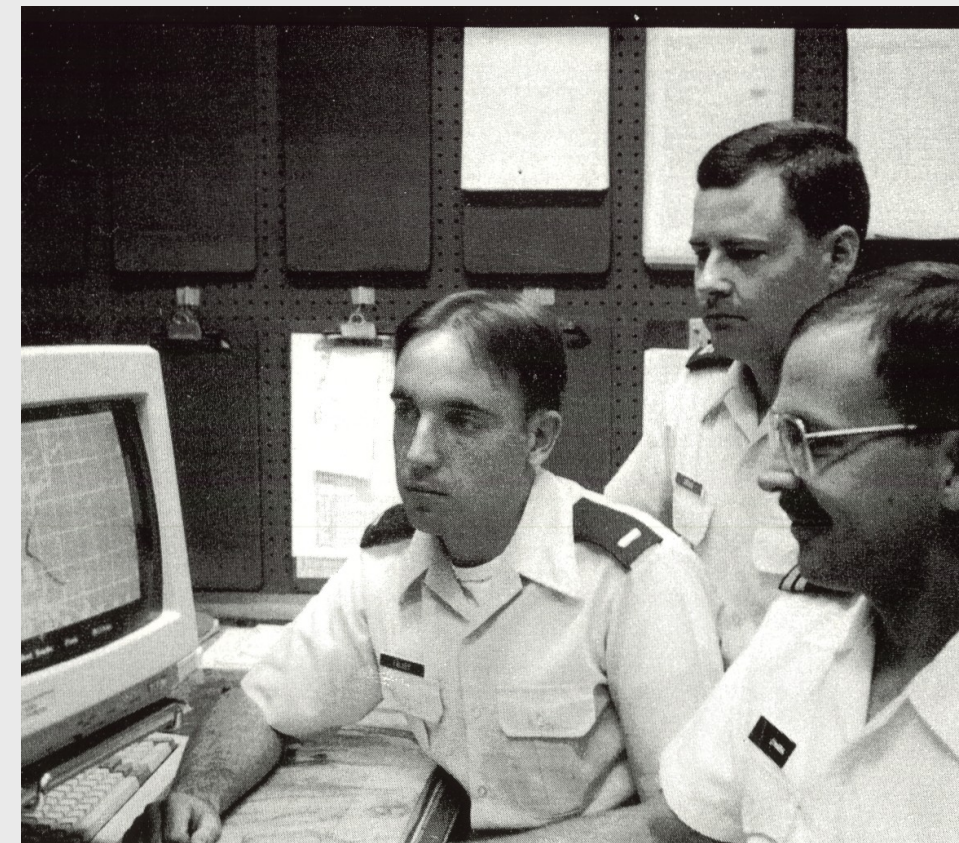
1984 JTWC and PACOM TC Warning Network challenged by RADM G. W. MacKay, COMNAVFORJAPAN, to make a 50% improvement in forecast position accuracy.
- Negative assessments of TC forecasting capability were made in view of JTWC's forecasts of Super Typhoon Abby (1983) as the cyclone passed east of Honshu island, Japan.

1985 Mr. Frank Wells becomes the first JTWC civilian Meteorologist and fills new position of JTWC Technical Advisor.



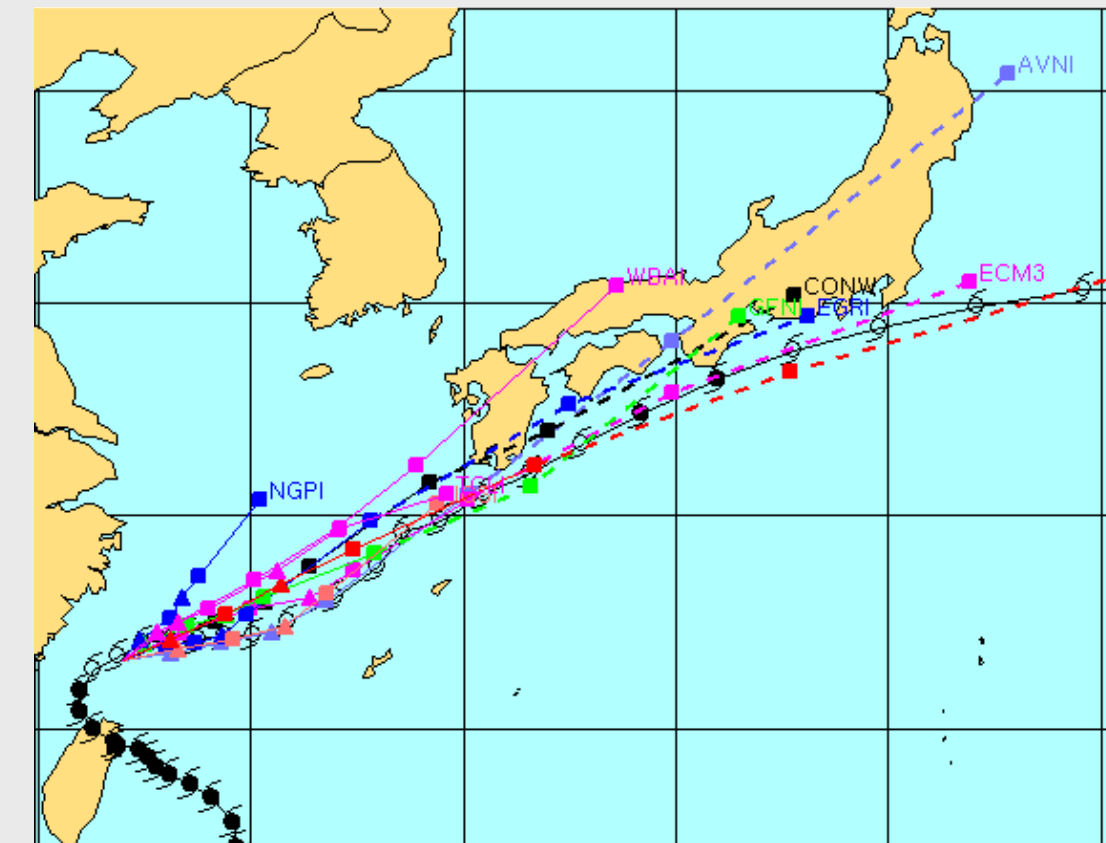
1988 Five manpower allocations added to JTWC to compensate for loss of WC-130s/54WRS.

1988 The Automated Tropical Cyclone Forecasting (ATCF) system is installed at JTWC and AJTWC.



THEN

JTWC director Bob Falvey (then 1st Lt Falvey) works with Pacific Fleet Oceanographer Capt John O'Hara (then LT O'Hara) on the first version of ATCF.



NOW

Displayed in the ATCF shot above of Typhoon Sinlaku is the TC's best track, various TC trackers used by the TDO, the consensus track of CONW, and JTWC's forecast. (Notice that JTWC beat CONW on this forecast!)

1989 JTWC hosts 30th annual Tropical Cyclone Conference.

1989 Naval Satellite Display System Geostationary (NSDS-G) used to process high resolution geostationary imagery for TC positioning and intensity estimates for the western Pacific Ocean.

1990 JTWC acts as the operations center for Tropical Cyclone Motion field experiment (TCM-90); an intense data collection effort to better understand TC characteristics and improve forecasting capabilities.
- Support and funding for TCM-90 driven by challenge for improvement stated by RADM MacKay at the 1984 TCC.
- JTWC begins to provide TC bogus data for NOGAPS initialization.

1991 USAF Meteorological Imagery, Data Display and Analysis System (MIDDAS) becomes operational.

1992 Use of FNMOC Beta Advection Model as an objective TC track forecast aid begins.

1993 JTWC begins experimental use of "blended", "weighted", and "DAVE" (dynamically-averaged) forecast aids.
- DAVE comprised of NOGAPS, UK Met Office, Japan Typhoon Model, JT92, FBAM, OTCM and CSUM models or aids.
- JTWC is the operations center for the mini-field experiment TCM-93.

1996 TC track forecasts produced from the GFDN triple-nested movable mesh model with 1°, 1/3°, 1/6° resolution.

1997 Intensity skill baseline objective aid, based on climatology and persistence provided via ATCF.

1999 BRAC-directed relocation (1995) to Pearl Harbor, HI completed.
- Tropical Rainfall Measurement Mission data used for first time.

2000 USAF Mark IV P3I system, installed in PACOM.

- Client/server arrangement enables remote access and interpretation of data from sites at Kadena, Andersen and Hickam.
- Quikscat used operationally.
- JTWC terminates naming western Pacific Ocean TC's and adopts policy of adding WMO-designated tropical names.

2001 Simple intensity forecast tool based on climatology and persistence out to 120 hrs, ST5D, implemented on ATCF.
- JTWC disseminates TC warnings for eastern Pacific Ocean.

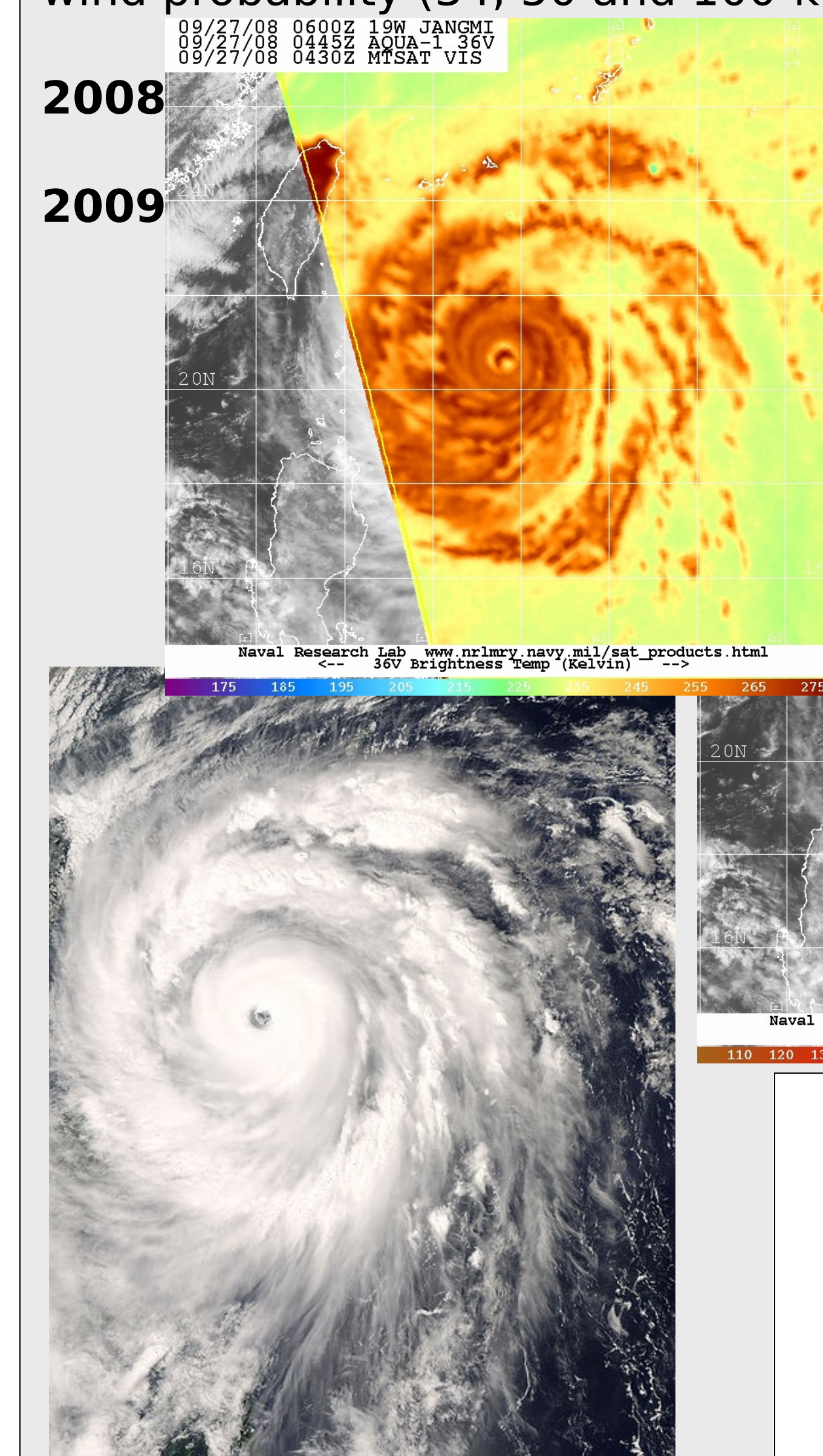
2002 Intensity forecast aid using climatology, persistence and real-time atmospheric and oceanic parameters, STIP, implemented on ATCF.
- SAFA beta test conducted and finding indicates highest forecast skill provided by consensus of 5+ dynamic models.
- Multi-model consensus (CONU) comprised of NOGAPS, UK MET, JMA Global Spectral, JMA Typhoon, GFDN, GFS, AFWA MM5 and COAMPS implemented on ATCF.

2003 JTWC begins issuing 120-hr TC forecasts for the Northwest Pacific Ocean after two years of development and testing.

2006 JTWC, NHC and CPHC begin issuing wind probability (34, 50 and 100-kt).

2008

2009



Our ability to detect tropical cyclones has evolved substantially throughout the last five decades. Images of Super Typhoon Jangmi a clockwise from bottom left: MODIS image; AMSR-E 36 GHz microwave image; AMSR-E 85GHz PCT microwave image.

